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TECHNETIUM-99m POLYPHOSPHATE BONE IMAGING: A QUANTITATIVE METHOD FOR ASSESSING BONE HEALING

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TABLE OF CONTENTS

LIST OF FIGURES

FOREWORD
(Nontechnical summary)

With the advent of bone grafting techniques to replace postsurgical or traumatic skeletal defects, the need has arisen for a technique to evaluate adequately and quantitatively the rate of bone healing in the graft area. The development of technetium-99m phosphate agents for bone scanning and improved imaging techniques suggest that scanning methods may be used as quantitative techniques for determining the rate of bone healing. Therefore, this study was done in an attempt to evaluate the efficacy of sequential scanning as a method of following the status of bone grafts.

Freeze-dried cancellous autografts (Group 1) and freeze-dried cortical segmental allografts (Group 2) were transplanted into surgically created 2-cm defects in the distal ulnas of adult mongrel dogs. Fresh autologous bone was inserted as a control graft in one ulna while the experimental bone graft was inserted in the contralateral ulna. Group 1 autografts were used to evaluate the effects of freeze-dried autologous bone graft healing while 14 Group 2 allografts were transplanted to study the graft material usually provided by the U. S. Navy Tissue Bank.

Sequential bone graft imaging was done as follows: 0.5 mCi/kg body weight of technetium-99m polyphosphate was given I.V. Scans were obtained on an Anger camera 2 hours after dosing. Photographic records were made, and the data stored on magnetic tape for later computer retrieval and processing. Bone images were obtained on each dog at 2, 4, 6, 8, 12, 18 and 24 weeks postgrafting. Roentgenograms were also obtained at the same times as the scans and were compared.

Both graft imaging techniques revealed either healing or nonunion, but the bone scans depicted the fate of the graft 5 to 8 weeks earlier than the roentgenograms. When healing occurred, the radioactivity at the graft-host junctional areas progressively migrated together, coalescing into one central peak. This provided a dynamic measure for determining the rate of bone healing.

Standard methods of evaluating bone grafts include x ray, tetracycline labeling, tissue biopsy, and biomechanical testing. All have limitations of being either destructive, subjective or insensitive. The scan method avoids these limitations and provides a method of quantitating the rate of bone healing that can now be objectively applied in identifying the most effective bone graft materials. Likewise, it may be used to evaluate tissue graft modifications which may be proposed to potentiate the best features of a particular graft material. Early identification of a fracture destined to nonunion can, for example, substantially shorten a patient's clinical course by clearly defining the timing of early operative intervention.

computer foretold the eventual fate of that graft as early as 8 weeks before identifiable graft resorption was evident radiographically. This new dimension of being able to predict bone graft healing was an unexpected bonus.

IV. DISCUSSION

The capacity to quantitatively assess the rate of bone healing has been unavailable heretofore (Figure 4). The ability to sequentially utilize this approach without fear of graft alteration is a significant advantage of the radioisotope scanning techniques. Other methods, using roentgenograms, tetracycline labeling, tissue biopsy or biomechanical testing, all suffer from limitations of being either destructive, subjective or insensitive.[1] The use of technetium-99m polyphosphate bone imaging as a new method of assessing bone healing allows objective evaluation of different bone grafting materials to determine which is the most successful. Likewise, this technique may also be used to evaluate tissue graft modifications which may yield better graft-host acceptability.

The ability to obtain early and sequential technetium-99m polyphosphate bone scans to predict bone healing provides another potentially important clinical tool. Early identification of fractures destined to nonunion can substantially shorten the clinical course of patients by reliably indicating early operative intervention. In addition, the evaluation of the pattern of technetium-99m polyphosphate activity at the site of bone repair may provide an important tool in guiding the clinician to determine what period in the healing process a patient may resume physical activity after a fracture or a bone graft procedure. Results of this study suggest that technetium-99m polyphosphate bone imaging will play an important role in evaluating the incorporation of massive bone

ABSTRACT

A new gamma scanning method has been developed for quantitating and assessing the rate of bone graft healing with technetium-99m phosphate bone-seeking radiopharmaceuticals. This recently developed radiopharmaceutical was utilized to evaluate graft materials placed in surgically created defects in the ulnas of mongrel dogs. It was found that radiopharmaceutical scanning is more sensitive for serial assessment of the bone healing than roentgenography. This new method has the potential of being an extremely useful clinical tool in the evaluation of healing of various skeletal abnormalities.

replacements with half- and perhaps whole-joint transplants which are now being investigated with increasing frequency. Correlating this, with possible evaluation of the graft and its surrounding host bone, with biopsy specimens may yield even further valuable information about the healing process in bone.

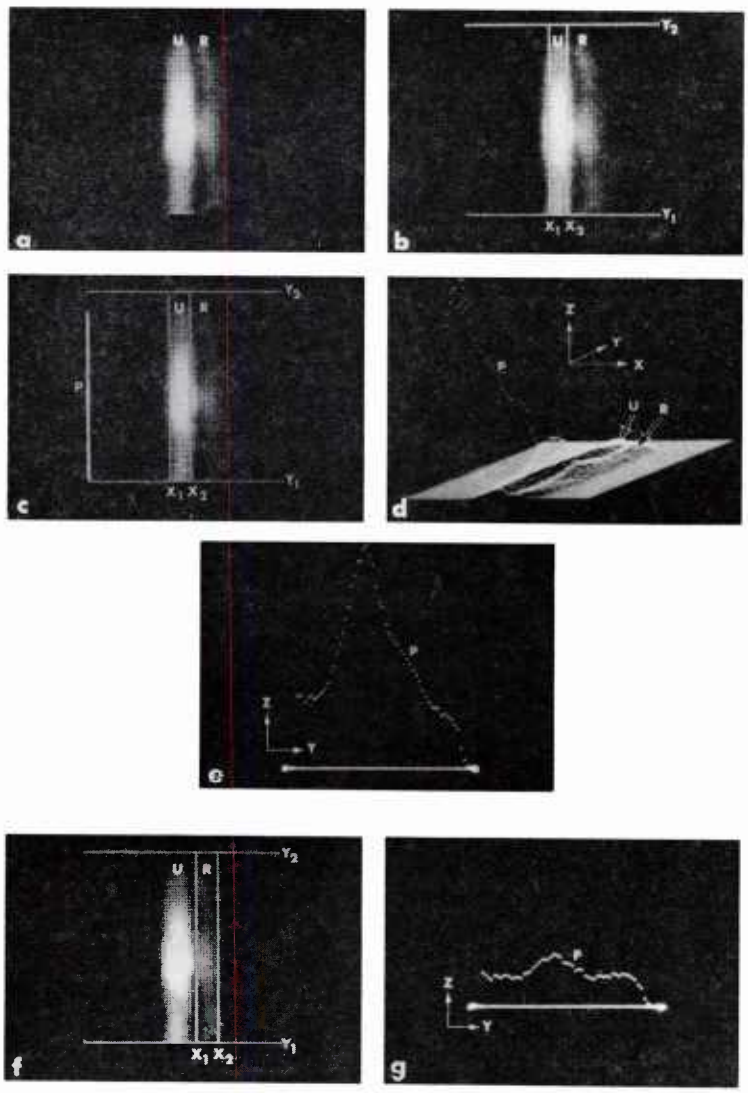

Figure 4. Data processing by the computer (image a) is accomplished by framing the ulna (U, image b) and storing the sum of each seven channels between X_1 and X_2 in the corresponding first channel of the profile at the far left (P, image c). This integrated profile may be displayed isometrically (image d) and separately (image e) for analysis and teletype output. Similarly, the radius is also framed (R, image f) to give an integrated profile (image g).

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A new gamma scanning method has been developed for quantitating and assessing the rate of bone graft healing with technetium-99m phosphate bone-seeking radiopharmaceuticals. This recently developed radiopharmaceutical was utilized to evaluate graft materials placed in surgically created defects in the ulnas of mongrel dogs. It was found that radiopharmaceutical scanning is more sensitive for serial assessment of the bone healing than roentgenography. This new method has the potential of being an extremely useful clinical tool in the evaluation of healing of various skeletal abnormalities.

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